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Procedia CIRP 47 (2016) 555 – 560

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Product-Service Systems across Life Cycle

Life-Cycle-Oriented Product-Service-Systems In The Tool And Die Making Industry

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Abstract

The tool and die making industry from Western Europe, characterized by single and small series production, faces increasing global competition with low-wage countries. Challenges are the increasing product-derivatization, shorter product life-cycles and lower factor costs of global competitors. The Western European high quality tool and die making industry is not able to face the increasing cost pressure, caused by the international competition, by reducing the acquisition price. Therefore prices are insufficient as a differentiation criterion. However, differentiation is possible through individual services replenishing the product. The solution presented in this paper concerns the configuration of a customized life-cycle-oriented Product-Service-System that incorporates product and service modules to address clients' preferences.

Peer-review under responsibility of the scientific committee of the 8th Product-Service Systems across Life Cycle

Keywords: Tool and Die Making Industry; Product-Life-Cycle; Product-Service-System; Smart Tools; Servitization

1. Introduction

Due to its key position between product development and series manufacturing the tool and die making industry is significantly influencing the manufacturing sector [1]. As the enabler of product development, it is the base for the high-performance manufacturing sector in Western Europe [2]. The tool and die making industry is one of the major influencing factors to ensure production of high quality products at high quantity and economical prices [1, 3, 4].

For a while, established companies from traditional tooling countries see themselves more and more faced with new competitors from Asia and Eastern Europe. Those increased their competences and will continue expanding. As a result those firms serve more frequently the same markets as the Western European tool and die making industry [5]. Due to lower factor costs in countries like China, established market participants can not differentiate via tool prices to remain profitable in competition [6]. Especially considering that the tools' quality is adjusting as well, this factor is no longer a unique selling proposition to justify higher prices. Shorten tools' life cycles enhance the price pressure to tool making firms as well [7]. In addition the world economic crisis in 2009/2010, from which the European branch has not completely recovered until now, showed that new strategies and product portfolios are necessary to ensure long-term competitiveness [8, 9].

Therefore it is advantageous to expand the product range horizontally to the customers' value creation process. This range of services is called Product-Service-System and means the integration of up- und downstream costumer relationship into the product portfolio [10].

This article considers the potentials and challenges, which are given by the usage of Product-Service-Systems, like increased customer loyalty and higher profit margins on the one side and necessary new abilities on the other side, as well as their design principles. Furthermore different models are analyzed, that describe the design of those systems and the need for a successful implementation into the company's product portfolio. After following this paper will especially explain the work at the Laboratory for Machine Tools and Production Engineering (WZL) at RWTH Aachen University of creating individual methodologies to apply those Product-Service-Systems to the tooling branch and its special circumstances. The paper consists of 3 chapters which will illustrate more detailed the mentioned aspects of the

Peer-review under responsibility of the scientific committee of the 8th Product-Service Systems across Life Cycle
doi:10.1016/j.procir.2016.03.217

motivation to implement Product-Service-Systems in the tooling industry from current challenges, Product-Service-Systems as a possible answer for a changing competition and customized Product-Service-Systems in the tooling industry. Some short concluding remarks will finalize the paper.

In the following, the word "tool" is used to describe tools as well as dies. Therefore, companies of the industry are described by the expression "tool making company" and the industry itself by the expression "tool making industry".

2. The Western European Tool Making Industry

2.1. Overview of the Western European Tool Making Industry

The Western European tool making industry is characterized by small and medium-sized enterprises with a high product competence [11]. In Germany e.g. about 80% of the totally approx. 54,000 employees are employed in companies with less than 20 workers [12]. The product range includes die-casting-, sheet- and massive forming- as well as injection molding tools and varies depending on the country. In Portugal, for example, 91.5% of the production is attributable to injection molding tools, whereas Germany shows a balanced output of sheet- and massive forming tools (45.3%) and injection molding tools (49.6%) [11]. However, their commonality is the sharp drop in sales during the world economic crisis in 2009/2010 between 24% (Austria) and 40% (Spain). Up to this day not all markets have recovered completely from these consequences. On the one hand for example, Italia, as the second largest producer of tools in Western Europe with a production value of 4,320 M. € in year 2014, still has a lower output then before the crisis in 2008 (5,352 M. €). Spain also could not reach the pre-crisis level yet (2008: 1,057 M. € / 2014: 891 M. €). On the other hand countries with a positive general economic situation, like Germany, already exceeded the pre-crisis level (2008: 10,715 M. € / 2014: 10,772 M. €) or Portugal (2008: 56 M. € / 2014: 84 M. €) [8, 9].

2.2. Potentials and Challenges for the Western European Tool Making Industry

To ensure the competitiveness in future, it is important to diversify from your competitors. Schuh et al. identified five factors of value creation, which have to be addressed nowadays by the Western European tool making industry to ensure their operative excellence [13]. These five factors are life-cycle costs, time-to-market, innovation, quality and productivity.

Life-cycle costs: Experts assume that 60% of total production costs are determined by the production tool and the aspects like maintenance and repair [14]. Innovative tool concepts enable customers to realize significant cost-saving potentials over the product's life-cycle because of the tools' high productivity. Therefore, tools' life-cycle costs become one of the most important lever [15].

Time-to-Market: Due to its key position between product development and series manufacturing the speed of the order processing is a major influencing factor for the time-to-market of a new product. In times of decreasing product life-cycles the tool making's influence of the product success increases constantly.

Innovation: Innovations constitute an important factor for enterprises in high wage countries. Novel processes and tool concepts enable an efficient production and therefore an active contribution to the customer's product development [15, 16].

Quality: To ensure a high customer satisfaction a high quality perception is needed. Therefore not only the tools' quality needs to meet the requirements but also the interaction between tool and machine has to be optimized. The only way to achieve this is by using innovative organizational measures and technology developments, e.g. automated sensor-actor systems [17].

Productivity: The importance of acquisition price in the competition can be decreased by reducing tools' life-cycle costs. For that, high tool availability and thus a high productivity in use must be addressed. However, it can be hard for the costumer to perceive this value because of the challenging measurability.

Even though tool making industry in Germany and most of the other Western European countries are in a good general economic situation again, as shown in Chapter 2.1, the companies will face new challenges in the future. To manage these challenges it will not be sufficient to only address value creation in terms of life-cycle costs, time-to-market, innovation, quality and productivity.

As a result of the still raising expertise of Asian and Eastern European companies, companies from these countries will compete with the established market participants on a comparable quality level [18].

Considering the higher production costs in Germany than in Asia, the actual tool price per kg nevertheless can be used as an indicator for the tools' quality and complexity. In Germany, as a representative of an established market offering high quality tools, this price is 16.67 €/kg. Whereas in China, as a representative of a raising market, it is only 8.30 €/kg [7]. However, it must be taken into account that the Chinese tool making industry is highly inhomogeneous, so that isolated companies are already able to produce high-complex tools [11].

The lower factor costs of global competitors set companies from high-wage countries additionally under pressure. For that reason it is difficult for them to enter the competition over the price of the tool [19].

Especially the tool making industry is also pressurized by shortened tool life-cycles and the advancing product diversification, which implicates decreasing tool budgets [20].

The combination of raising importance of global competitors from low-wage countries and their lower factor costs as well as the shortened tool life-cycles leads to the fact that differentiation by operative excellence of value creation only will not be able to keep the Western European tool making industry successful in competition [21].

3. Product-Service-Systems – A possible answer for a changing competition

3.1. Potentials and challenges of Product-Service Systems

An efficient and effective possibility to counter the competition is using Product-Service Systems. Belz defines these as systems, which establish or support the customer connection and aim for creating advantages for the customer as well as the own company. To achieve a unique added value by individual solutions material and immaterial goods and services are connected. [22]

To examine the existing potentials of Product-Service-Systems, the advantages and the actual state of implementation need to be compared. Advantages of these Product-Service-Systems are higher profit margins because of integrated services as well as new growth opportunities in saturated markets and long-term customer relationships [10]. Long-term relationships refer to the tool's lifecycle. Nowadays the tool making companies often offer tool manufacturing only. Operating in the up- and downstream customer integration provides various new opportunities for the tool making companies as well as their costumers [23].

Nevertheless today only 15% of tool making industries' turnover account for services. These are located in early product life-cycle phases and often only offer a hardly quantifiable customer added value [24].

The analysis of the German-speaking market in the framework of competition „Excellence in Production" is a reference to the potential of Product-Service-Systems (see Figure 1).

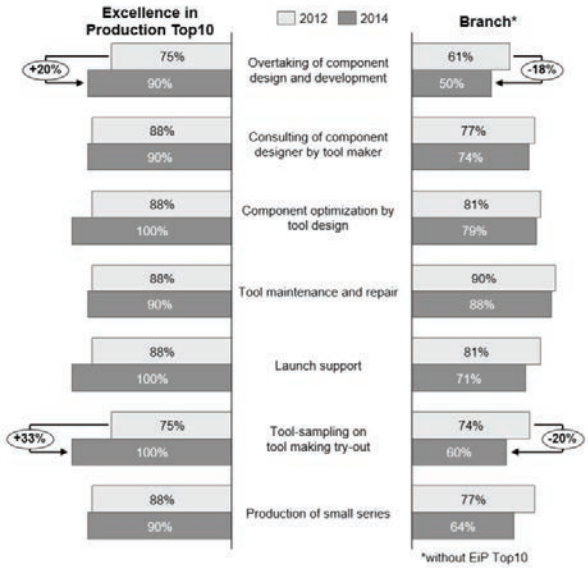

Figure 1 Potentials of Product-Service-Systems [25]

It is recognizable that product-related services, like overtaking of component design and development or launch support, represent a significant and still increasing role in the product portfolio of successful companies. Whereas the percentage of less-successful companies which also offer these services is up to 40% lower. Besides future expectations also see an increase of the importance of up- and downstream customer relationships [26]. Overall Product-Service-Systems help tool making companies to address all five factors of value creation by Schuh et al. Life cycle costs and productivity can be reduced for example by individual maintenance processes. Furthermore the time-to-market can be reduced by integration into product development. All the experiences help the tool making companies to guaranty their tools' quality and increase them continuously.

Exploiting these potentials also results in a variety of new challenges for the tool making industry [17]. The new product range and services around the physical core product require a new thinking about the corporate strategy and the business model [27]. Only if service and customer orientation is deeply entrenched inside the corporate culture, Product-Service-Systems can be successful communicated to the customer. This means that processes need to be focused on a company-wide acting service management and that the employees not only need to be taught in product trainings but also in dialogue strategies and behaviors [28].

Especially for the tool making industry, characterized by mostly small-sized companies, it is hard to position themselves as a global service provider because financial as well as personal resources are missing [5]. Therefore international partner networks are needed to offer service activities worldwide. Thereby it is also necessary for the tool making industry to differentiate from pure service providers, which appear as new competitors because of the new services and highlighting its advantages [10].

3.2. Structure and design principles of Product-Service Systems

The general structure of Product-Service-Systems conveys the model according to Belz (see Figure 2) [22]. According to this a Product-Service-System is divided into seven shells, which expends around the physical core product. With rising distance to the actual product these are:

Product system: The Product system has got the smallest distance to the core product and includes e.g. toolkits, smart products or integrated electronic.

Range: The range describes additional services in terms of usage- and purchasing bundles, which are clearly separated from the core product.

Services: Immaterial services mean to provide services connected to the tool like costumer services, financing possibilities or teachings.

Service integration: Service integration expends classic services and integrate them into customer workflow, e.g. research cooperation, development and logistics or customer support in the production.

Integrated project management: Integrated project management achieves a general customer relief through e.g. overtaking overall project or coalition management.

Innovative cooperation: Innovative cooperation means the joint development of innovative problem solutions with the collaboration of the customer.

Emotional profile and costumer experience: Addressing the costumer's emotions includes aspects like image, trust or

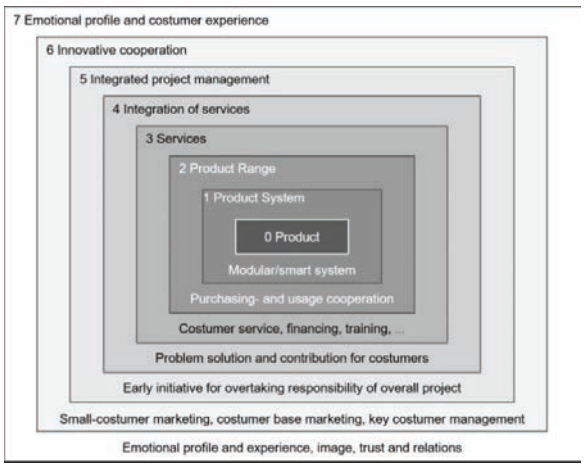

Figure 2 General structure of Product-Service-Systems according to Belz [21]

relationship management and influences all six underlying shells, e.g. field service or the influence of emotionality in product design.

By using this clear shell structure, an invisible, unstructured and in the end not demanded range of services can be prevented. Instead an awareness of delivered services can be brought to the customer, which leads to a better billability of the services. Nevertheless it is important not to lose the focus on the core product for the benefit of product surrounding services, to avoid losing customers.

In addition to the structure Belz et al. define six principles which need to be addressed by the company while constructing the Product-Service-System [29]. By meeting these requirements Product-Service-Systems also differentiate from general service conglomerates. Central aspect of a Product-Service-System is the *principle of integration*. Several components may not just be assembled, but rather be specifically integrated into each other to make sure to achieve synergies. Simultaneously it is important to particularly care about the *principle of compensation* to ensure that services can be clearly invoiced. The *principle of participation* describes the customers‘ influence on the creation process of the Product-Service-System to develop new problem solutions. Further Belz et al. define the *principle of evolution*. Due to that the dynamic development of the Product-Service-System itself is obligatory necessary to guarantee differentiation from competitors as well as surpassing customers’ wishes [26]. Moreover Product-Service-Systems need to show a long-term design because only in this way a sustainable success for customer and company can be warranted *(principle of long-term orientation)*. Finally the *principle of relevance* is shown. This refers to the services‘ and service provisions’ focus on customer relevant areas to avoid absent customer request because of a wrong orientation.

To realize the introduced Product-Service-Systems‘ potentials and provide them successfully to the market, based on the design principles above, an active development addressing the corporate strategy and customer benefit is needed. [30, 31] Many different models for a specific structure are available in literature and they all build up on the presented circumstances in Chapter 3.2. Named examples include the customer individual value based Product-Service-Systems design by Bauer [32] or Product-Service Engineering by Steinbach [33]. Also Belz et al. [29] offer a model for designing Product-Service-Systems named “concept of an integrated service management”, based on their model which describes the general structure of a Product-Service-System. Thereby service designing, service commercialization as well as service creation are central tasks. In the course of service designing products and services are determined by the company. Out of the determined services the customer selects the problem solution which fits best to his requirements and which are developed and arranged in cooperation between company and customer. The model by Belz as well as all the other existing ones show different kinds of weaknesses. For example the use of resources is unknown or the core product’s life-cycle is not considered in the Product-Service-System’s creation process.

4. Customized life-cycle-oriented Product-Service-Systems in the tool making industry

Nowadays services are often offered reactive, which leads to services getting out of hand and an unstructured and non-standardized product range. To avoid this, several models have been introduced in Chapter 3.2. However, their commonality is the missing specific reference to the tool making industry and its individual customer requirements. Thus a specific approach for the tool making industry needs to be developed.Therefore on the one hand typical Product-Service-Systems in the tool making industry have been identified [34] and on the other hand methodologies for designing life-cycle oriented Product-Service-Systems have been developed [30] at the WZL.

Eversheim et al. see a possible differentiation in competition over superior know-how in combination with high flexibility and service quality in the field of customer products. For this a model was developed which uses the industrial value-creation chain as a framework for designing a Product-Service-System, pictured diagonally in the model (see Figure 3).

During product development services like component development or component optimizing can be offered. Likewise Eversheim et al. define services during the next steps of the value-creation chain.

The tool making industry can achieve an upstream

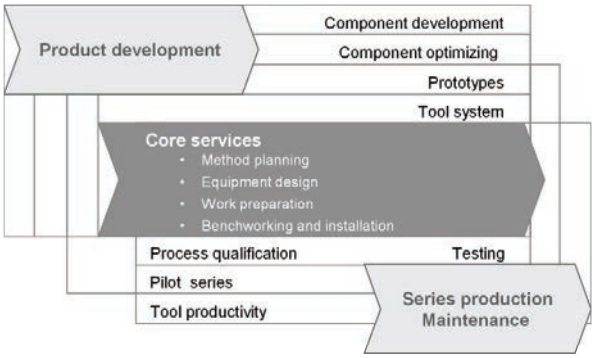

Figure 3 Product-Service-Systems in tool making industry by Eversheim [34]

integration in product development by offering component development and optimization as well as by providing tool prototypes. Even tool systems can be a central approach for increasing customers' benefit [35]. These systems include not only the tool itself, but also the tool holder, the tool magazine and the tool changing system.

In case the tool making company assumes the coordination of procurement of all necessary tools and dies, the customers' efforts and number of interfaces are decreased. Simultaneously the tool making industry needs to build up new competences in efficient process management as well as maintaining an appropriate supplier base.Moreover the tool making industry can strive for a downstream integration into the series manufacturing. This can be implemented by process enabling or pilot series for example.

A qualitative study by the WZL investigated the factors which influence the purchase decisions in the tool making industry as well as the factors which play a role in the execution of services. In that process missing services in case of global tool procurement could be identified as the second largest disadvantage from the point of view of the customer [22]. In the context of an increasing amount of new and advanced sensor technologies it is also a suitable opportunity for tool making companies to provide a guarantee of tool productivity. Smart tools as the enabler of such systems play a significant role in using and designing these potentials [36]. Only by using smart network and sensor technology as well as high-performance and safe communication technologies this new services can be offered [37]. The analysis of the created data allows the tool making industry to monitor and improve the tool quality as well as to provide repairs and maintenance strategies [38]. So the tool availability and a constantly high process quality can be guaranteed to the customer.

It is important, that these are possible parts of a Product-Service-System. The explicit design phase must be used to identify services and products which fit to the companies' abilities and strategic aims [28].

Nevertheless the approach by Eversheim et al. do not include a modular design approach of Product-Service-Systems, it only introduces possible configurations. Kühn developed a life-cycle-oriented Product-Service-System for the tool making industry, which enables tool making companies to develop customized systems [30].

Central point is a modular Product-Service-System in the tool-making industry as a model, which adds the tools' life-cycle (horizontally) to the depth of the shell model by Belz (vertically). Therefore a two-dimensional matrix structure has been developed, which refers to the discrete phases of the tools' life-cycle and specific integration levels (see Figure 4). Inside the matrix concrete forms of a Product-Service-System regarding to a specific part of the tool's life-cycle on the one site and with a specific distance to the core product on the other site can be found.

The sixth shell of Belz' model, the innovative cooperation, depends on the tools' life-cycle and is per definition located in phase of tool development. The seventh shell, the emotional profile and customer experience, is considered as a part of the product system, called "emotional tool". Referring to Belz it addresses an overarching goal with influence on all parts of tools' life-cycle.

The modular Product-Service-System by Kühn is meant to be read and applied as described in the following example. The tool making company can offer a customer a prototype tool in the phase of the tool development. As a next integration level the company can offer consulting of process design in order to achieve the shell "Services". In the continuing process of the different phases of the tool, the activities can be offered to the customer depending on the knowledge and opportunities of the tool making company. Other phases and principles can be read in analogy with the same logic. The company can choose out of specified modules of Product-Service-Systems regarding the tools' life cycle and the distance to the core product, so the influence of their own abilities as well as the customers' needs can be pictured. Of course different layouts are possible, but this model offers a transparent way of getting impressions of Product-Service-System's layout for the tool making industry.

During the creation of a Product-Service-System on the basis of the model according to Kühn the six principles of Belz have to be addressed to ensure a successful offering to the customers.

The tool making companies have to choose suitable modules, based on their strategic orientation and in cooperation with their customers. For a successful identification and arrangement of these modules, it is important to identify potential benefits for the company

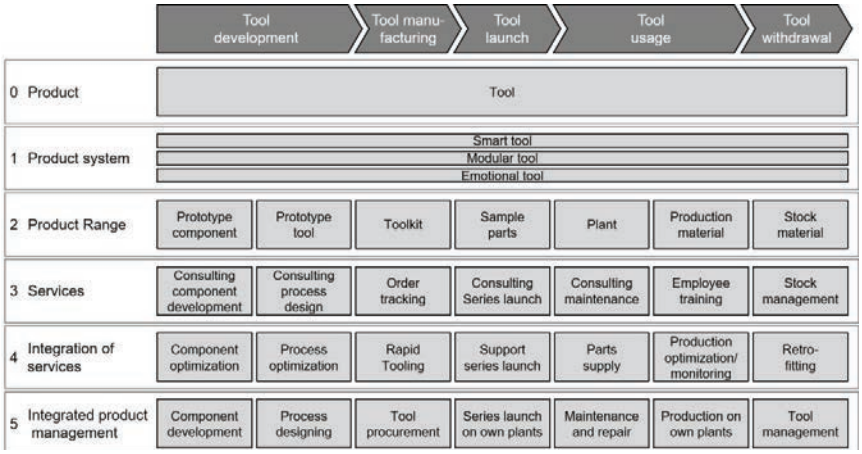

Figure 4 Modular Product-Service-System by Kühn [30]

customers. This categorization bases on the four customers benefit potentials by Frick: Innovative contribution, complexity reduction, economy of time and purchase costs [39]. A successful company cannot address all benefits and has to concentrate on selected services and activities for their customers.

4. Concluding remarks

In this article costumer-individual life-cycle oriented Product-Service-Systems have been shown. They represent opportunities, which allow the established tool making companies in Western Europe to remain profitably in the competition with companies from Asia or Eastern Europe.

Therefore at first the general structure of Product-Service-Systems has been introduced as well as important designing principles. Building up on that the specific requirements of the tool making industry in connection with the rising new possibilities and challenges have been discussed.Out of that, a modular life-cycle-oriented Product-Service-System, which is specifically tailored to the requirements of the tool and die making industry, has been presented. It enables a customer individual configuration of Product-Service-Systems.

Acknowledgements

This project is funded by Deutsche Forschungs-gemeinschaft (DFG) - German Research Foundation.

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